AD-A080 033 OREGON STATE UNIV CORVALLIS SCHOOL OF OCEANOGRAPHY
EXPOSURE. A NEWSLETTER FOR OCEAN TECHNOLOGISTS. VOLUME 7, NUMBE--ETC(U) F/G 8/10
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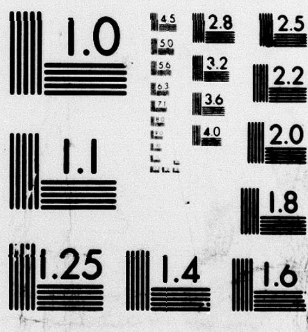

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER Vol. 7, No. 5	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) EXPOSURE. A newsletter for ocean technologists. Volume 7, Number 5.	5. TYPE OF REPORT & PERIOD COVERED technical report.
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Dr. Roderick Mesecar (Ed.)	8. CONTRACT OR GRANT NUMBER(s) N00014-79-C-0004
9. PERFORMING ORGANIZATION NAME AND ADDRESS School of Oceanography Oregon State University, Corvallis, OR 97331	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS NR 083-103
11. CONTROLLING OFFICE NAME AND ADDRESS NORDA, NSTL Bay St. Louis, MS 39520, Attn: Code 410	12. REPORT DATE Nov[redacted]79
	13. NUMBER OF PAGES 8
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) 12 9	15. SECURITY CLASS. (of this report) (U)
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

DDC RECEIVED JAN 31 1980 A

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Published every two months by the School of Oceanography, Oregon State University, Corvallis, OR 97331

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Ocean technology; instrumentation

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Contents: AXBT's for Oceanic Measurements, and Electromechanical Swivel Termination.

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EXPOSURE

vol. 7 no. 5 a newsletter for ocean technologists

AXBT's For Oceanic Measurements

The Airborne Expendable Bathythermograph (AXBT) system has been in use for oceanographic surveys for more than 8 years.[1,2] During this period an increasing number of instruments have been used for various scientific programs. AXBT's are manufactured to U.S. Navy design specifications and procured in large batches from a contractor successful in winning the bidding contest. Over the past 8 years, several manufacturers have supplied AXBT's to the U.S. Navy from which scientific programs have been supplied. While these units are similar in design and produce data outputs which satisfy the same Navy specifications, they all exhibit differences of significant importance to scientific users.

A question which remained unanswered regarding the accuracy of the overall AXBT system was the verification of probe descent rates. Some question regarding this parameter remained from differences noted in actual ocean tests.[3] To resolve this question, 13 Magnavox AXBT's were disassembled and fitted with small pressure sensors. Suitable electronics replaced the original temperature oscillator board, and the units were reassembled. Each was carefully weighed so that it was within one gram of its original weight. The external package was unchanged save for a small (~ 2 mm) hole in the nose leading to the pressure sensor. These special AXBT's were deployed on 10 November 1976 off Southern California. Ten good records resulted in a mean descent rate of 1.59 m/sec to 300 m depth. The standard deviation for these data was .043 m/sec. This value is 4.6 percent greater than the nominal value of 1.52 m/sec, but it is still within the ± 5 percent specification of descent rate.

November 1979

During the above described experiment, seven previously calibrated AXBT's were deployed while simultaneous salinity, temperature and depth (STD) profiles and Nansen Bottle casts were taken. This was to verify previous laboratory tests and calibrations. Unfortunately, the results of this experiment show large deviations in AXBT temperature versus STD values which were supported at a number of data points by Nansen Bottle reversing-thermometer data as shown in Figure 1.

Research into this difference revealed that the manufacturer had changed thermistors, the newer types having thicker coatings which greatly modified the thermal time

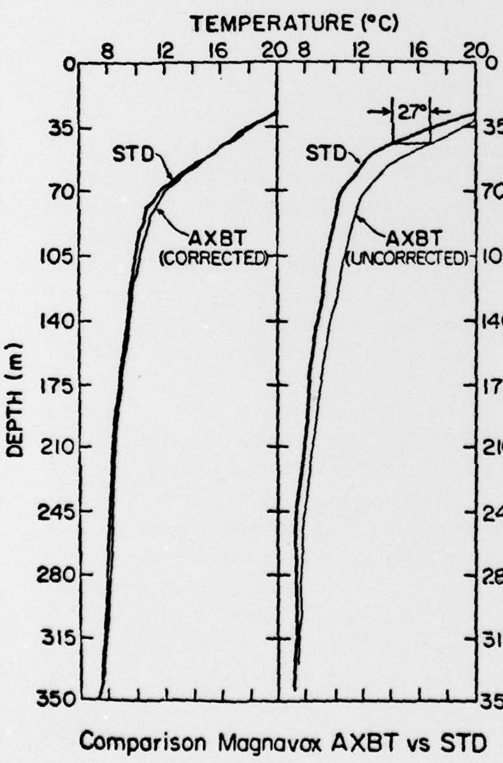

Figure 1.

AXBT traces versus simultaneous STD casts.

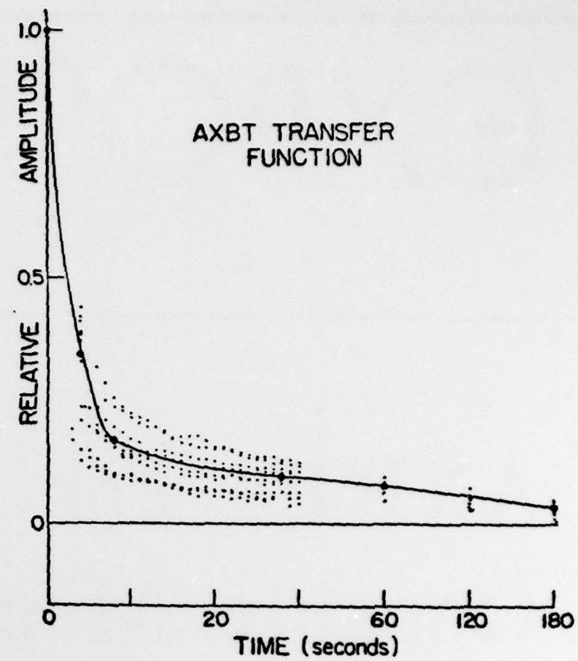

Figure 2.

Experimental estimates of response of AXBT's to a step function temperature input. Data are for ten instruments from five different production lots. The heavy curve is the fitted transfer function.

constant of the probe assembly. New time-constant measurements yielded the results shown in Figure 2. Unfortunately, fairly large scatter in the data exists due to uneven coating of the individual thermistors. Since the probes contain pairs of thermistors in series, there can be large differences in each thermistor in the pair.

Examples of a corrected and uncorrected AXBT trace verus a simultaneous STD trace are shown in Figure 1. The error has been reduced by a factor of 10 so that the uncertainty between AXBT/STD is now comparable with:

1) the uncertainty in the temperature/frequency calibration between different instruments, or

2) the inter- and intra-lot scatter amongst the units used in the time constant determination (Figure 2), or

3) the scatter in the observed times between probe release and the start of modulation (= transmission of temperature data), or

4) some combination of 1) to 3).

All items considered, the Magnavox AXBT accuracy is of order 0.3°C - 0.4°C with the largest errors occurring in the regions of highest vertical temperature gradient.

Hermes Electronics produced the most recent group of AXBT's for the U.S. Navy. Again the design is outwardly similar to other manufacturers' but contains several differences. The thermistors and oscillator are different from previous designs and in this case utilize glass head coated thermistors with a time constant of 300 to 500 milliseconds. Our tests have verified these figures which remove the serious time constant problem noted in the later Magnavox units. It was necessary to calibrate a quantity of these units to verify the predicted frequency to temperature relationship. A sample of 100 AXBT's from lots 18 and 20 were calibrated at 8°C and 25°C. Several AXBT's from this sample were also calibrated six points over the range of 0°C to 32°C. Analysis of these results showed that a good linear relationship over the range of 7°C to 26°C could be expressed by the following equation:

$$f = a + bT$$

where f = frequency in Hertz
T = temperature in degrees Celsius
and $a = 1425$, and $b = 37.18$

The mean, standard deviation, and range for the calibration points of 8.0°C and 25°C, respectively, are:

	8°C	25°C
MEAN FREQUENCY	1722.5 Hz	2354.7 Hz
STANDARD DEVIATION	1.68 Hz	1.44 Hz
RANGE	+5.4, -4.4 Hz	+5.3, -3.2 Hz

These calibration results are summarized in Figure 3 along with a

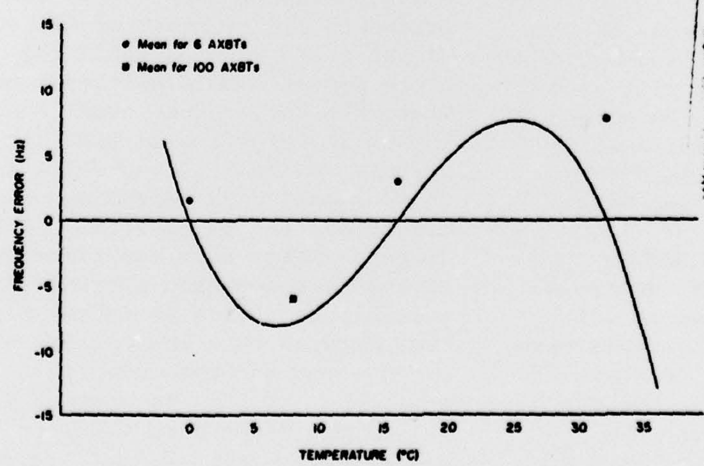

Figure 3.

Calibration data of Hermes AXBT's

plot of the theoretical probe error curve from the Navy straight line equation for all Hermes AXBT's.

A second group of 36 Hermes AXBT's were calibrated at 8°C and 25°C during October of 1979. These units were from lots 13 and 31. The results of these calibrations are:

	8°C	25°C
MEAN FREQUENCY	1723.9 Hz	2357.05 Hz
STANDARD DEVIATION	2.30 Hz	2.21 Hz
RANGE	+4.7, -3.6 Hz	+5.2, -3.2 Hz

The above data are for 35 instruments. One of the AXBT's showed frequencies below the mean values equivalent to about 2°C at 8°C and 2.6°C and 25°C. Discussions with the manufacturer indicated that this is most likely a failure of a trim-potentiometer in the probe assembly. Several incidents of this type failure have been noted during drop tests. The AXBT in question has been returned to the manufacturer for analysis and positive identification of the fault.

Recent discussions with the manufacturer indicate that the fall rate of this instrument is running near the upper limit of the ± 5 percent specification. This appears to be due to probe weights being on the heavy side. Comparisons of data from experiments tend to support this conclusion as well. Starting with lot number 50, a weight reduction of the probe will be instituted which will result in the fall rate being near the nominal 1.52 m/sec value.

Since 1974 we have used AXBT's manufactured by Magnavox, Motorola, and Hermes, Ltd. A group of 290 AXBT's manufactured by Motorola were used during January and February of 1974 in the North Pacific Ocean. A failure rate of 11 percent was sustained. The units exhibited a tendency to fail to transmit audio signals as the probe descended to some significant depth. It was suspected that the probe leakage was the cause of this. If a probe got well past the mixed layer depth at about 100 meters, it was not considered a failure.

During a second long term monitoring experiment in the North Pacific Ocean, Magnavox AXBT's were deployed on monthly flights between November 1974 and April 1977. Approximately 1300 AXBT's were deployed during this experiment. A failure rate of 10 percent was sustained by these units. All of these AXBT's were of the rotorchute type, which were the earlier portions of the total number built on this contract. Units manufactured later in the contract had the rotorchutes replaced with parachutes.

The third group of AXBT's were manufactured by Hermes, Ltd. and were used in a transequatorial experiment between November 1977 and February 1978. A total number of 1620 AXBT's were deployed during this experiment with a failure rate of 4.7 percent. Clearly, the latest design AXBT achieved better reliability than past AXBT's. It was noted that many of the failures were of a type not observed in previous experiments. This was evidenced by the start of the audio signal being delayed until the probe was at some significant depth where the temperature profile would appear to be offset in time (or depth). We call this problem a "late start" and, depending on its magnitude, it can be difficult to detect. After some experience of flying at a constant altitude, it is possible to notice an increase in time between when the carrier signal is detected and the audio is detected. If this late start is only a few seconds in time, it is quite difficult to detect and can therefore result in very misleading

data. This problem is due to the mechanism which detects release of the probe, and switches the audio signal to the modulator. An improvement in this area is clearly called for and would further reduce the field failures observed during our experiment approximately by 50 percent.

The standard U.S. Navy AXBT can be used for oceanographic purposes if appropriate calibrations are performed and applied to field results. Even though all units are produced to meet the same specifications, subtle differences between different designs affect performance in the ranges of accuracy expected for oceanographic purposes. Care should be exercised when using even the same manufacturer's units from lots produced at different times as running production changes can have serious effects on performance.

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[1] Sessions, M. H., W. R. Bryan and T. P. Barnett, "AXBT Calibration and Operation for NORPAX POLE Experiment," *Scripps Institution of Oceanography Ref. Series* No. 74-31, 19 pp. (unfinished manuscript) 1974.

[2] Sessions, M. H., "Aircraft Expendable Bathythermographs Used in NORPAX Experiment," *Exposure* II (3), 1974.

FOR FURTHER INFORMATION, CONTACT:

Meredith Sessions
Scripps Institution of Oceanography
Post Office Box 1529
La Jolla, CA 92037

Telephone: (714) 452-3032

Meredith Sessions is a development engineer at Scripps Institution of Oceanography, where he has been involved in the design of oceanographic instruments and mooring systems for the past 20 years. He has participated in developing current meters, a coastal wave monitoring system, and an AXBT calibration and aerial survey technique. The Coastal Data Network and the National Sediment Transport Study are two coastal programs he is presently engaged with.

Electro-mechanical Swivel Termination

Electric swivels have reliably provided the rotational electromechanical coupling needed with monitored biological sampling equipment at Oregon State University.[1]

A major part of the early swivel development effort was concentrated on achieving a mechanical tension transfer from the cable armor to the swivel body. After constructing and testing several unsuccessful versions of mechanical clamps for this purpose, an epoxy bonding (potting) technique was devised that worked well.[2] However, incorporated into this technique were procedural requirements that the technician had to dutifully follow. Because of the need for swivel applications on research vessels by diverse research personnel, it became apparent that we needed to develop a less-exacting swivel termination procedure.

The body of this article describes a swivel termination technique which incorporates commercially manufactured components where much of the procedural exactness for the termination has been removed from the technician's duties. Using this technique, most terminations can be made in less than 1 hour, regardless of the cable's diameter. Preliminary results of laboratory tests on these terminations have been very good.

Swivel Termination Technique

This electromechanical termination technique reverts to a combination of all-metal cable grips, which are commercially available. Figure 1 is a cut-a-way which shows how the grips have been applied and integrated into the electric swivel function.

Although the following description of the components and parts numbers are identified for 0.25-inch cable, equivalent components exist for cable sizes up to 0.5 inch. Because there is size latitude some grips can be used for more than one cable size.

Referring to Figure 1, the sequential steps taken to make this termination style are as follows:

- Apply over the 0.25-inch (1H25SA), Amergraph (U.S. Steel) cable a model BG 2144 Preformed Line Products (PLP) cable grip. The purpose of the grip in this application is threefold: 1) to form a strain relief between the cable and the swivel, 2) to contribute to the transfer of cable tension to the swivel body, and 3) to mechanically protect the cable from the second stage cable grip. Before applying the PLP grip, the cable eye needs to be cut off with an abrasive saw or grinder and the cut ends smoothed. When the PLP grip is in place, there should be 12 inches between the end of the Amergraph cable and the grip.

- The second stage cable grip is a Reliable Electric Co. Strandvise cable termination model (5253). This grip is slid over the PLP grip. At this point, the armor strands of cable are turned back on themselves at the PLP grip and cut off 2 inches from the bend. Next, the Strandvise grip is moved down and over the turned back armor strands. As noted in Figure 1, the Strandvise grip has spring-loaded jaws. These jaws, under load, are set and can only tighten with cable dimensional changes; it takes a high reverse force to release them.

- The first two steps provide all of the mechanical tension transfer ability to the swivel body. The Strandvise grip is then slipped into a bellhousing on the back of the swivel and secured with three screws. The split swivel assembly, before being secured into the bellhousing, is shown in Figure 1b. The bellhousing also accommodates and protects the electrical connector and splice junction between the cable and swivel. The final swivel assembly is seen in Figure 1c.

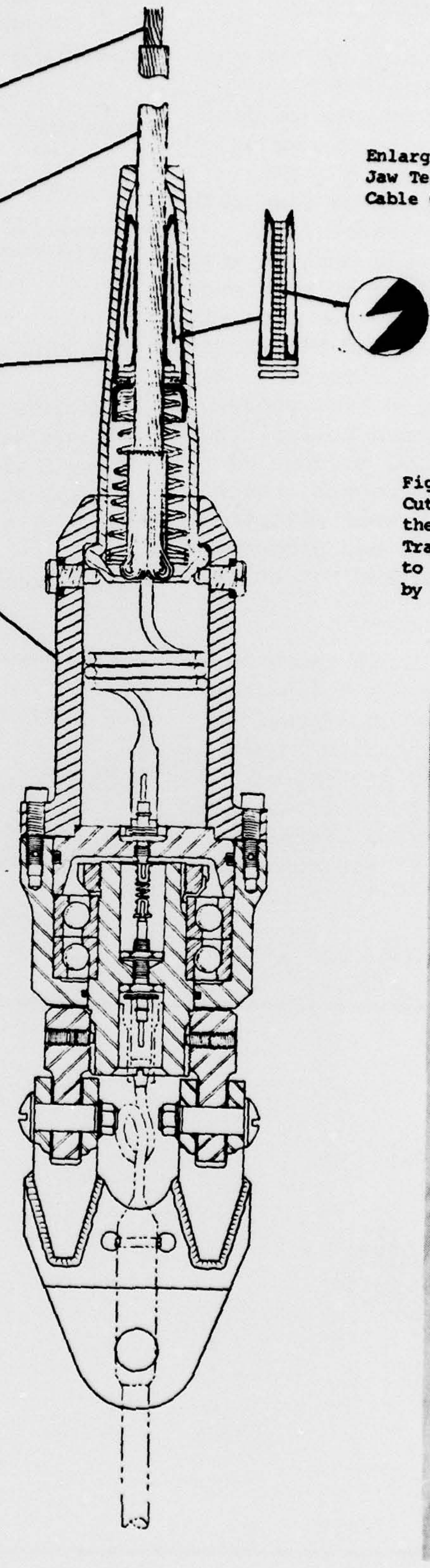


Figure 1a.
Cut-a-way View of
the Cable Tension
Transfer Technique
to the Swivel Body
by Using Cable Grips.

Figure 1b.

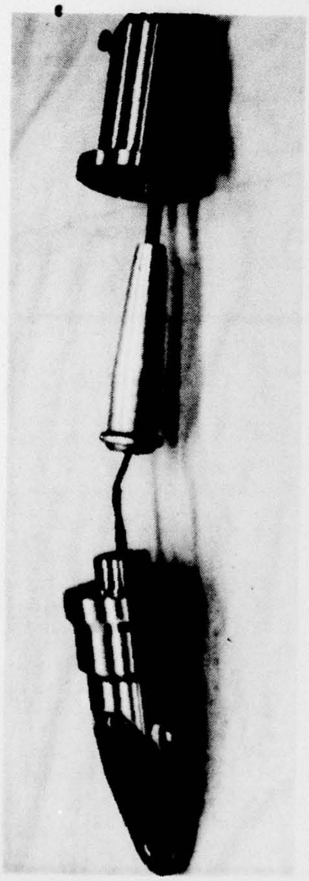
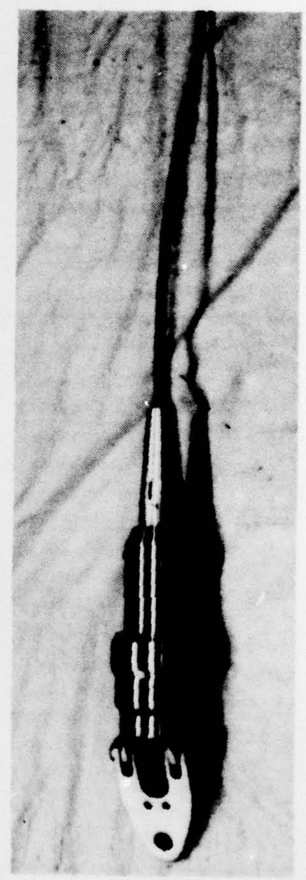


Figure 1c.



Testing Procedure and Results

A limited amount of testing has gone into this swivel termination. However, all of the results to date indicate that this concept can be readily applied with good safety margins. Testing has been done with 8-ft sections of the cable in a Southwark-Emery testing machine with comparable terminations at both ends. Roughly 300 pull tests were done with the applied tension being 50 percent of the cable breaking strength. At the end of this cyclic test phase, the cable was tensioned to failure. The cable failed at 92 percent of its rated breaking strength. Each failure test of the cable with this termination procedure has produced a parting in the cable and not at the termination.

Similar terminations and tests have been done for Amergraph 0.425-inch cable with similarly good results. After five hundred tension cycles on this cable, at 50 percent of breaking strength, it pull tested to 85 percent of its rated breaking strength. (This test was done with used cable.)

This termination scheme has proven so easy to assemble and so consistently secure that more tests will be scheduled under at-sea conditions.

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1 Mesecar, R., "Midwater Trawl System," *Exposure* I (1) 1973.

2 Mesecar, R. & D. Stein, "Armored Electric Cable/ Swivel Termination," *Exposure* III (6) 1976.

FOR FURTHER INFORMATION, CONTACT:

Rod Mesecar, Dennis Barstow, or Milton Rowland
School of Oceanography
Oregon State University
Corvallis, Oregon 97331

Telephone: (503) 754-2206

T A B L E O F C O N T E N T S

Dr. Rod Mesecar, Editor
E X P O S U R E
School of Oceanography
Oregon State University
Corvallis, OR 97331

Telephone: (503) 754-2206

FIRST CLASS MAIL